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Forest Service

Forestry Research West

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A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

Forestry Research West

In This Issue

Cover

Clean air is just one of the many attributes wilderness areas offer. Scientists at the Rocky Mountain Station have developed a new procedure to help land managers evaluate air pollution effects on Class I wildernesses. Details begin on page 1

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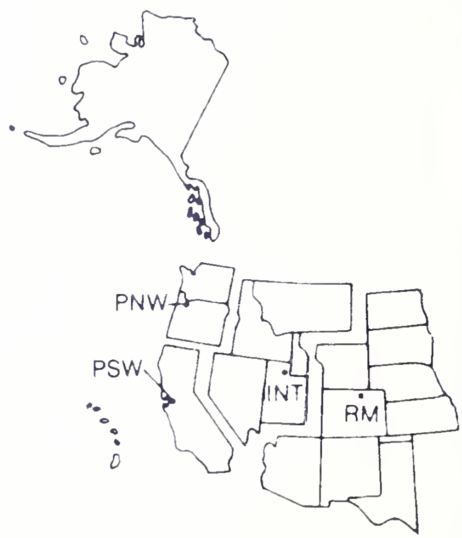


Screening air quality in Class I areas


Most wilderness visitors expect clean air—


but it's not always a guarantee.

President Bush, declaring that "too many Americans breathe dirty air", announced in June a $14 to $19 billion per year plan for beefing up the Clean Air Act and sharply reducing acid rain pollution.

Among the proposals called for are requirements for factories and plants emitting toxic air pollutants to use the best technology available to reduce overall emissions by 75 to 90 percent, cutting sulfur dioxide emissions by 10 million tons per year, and nitrogen oxide emissions by 2 million tons.

The President's annoucement is coupled with, and a reflection of, national, and even world-wide concern about global warming, the greenhouse effect, acid rain, and other air pollution-related issues.

Along with the urgent need to reduce pollutants, there is an equally pressing need to protect those areas that are still clothed in clean air. Some of our Nation's most pristine skies are in wildernesses and National Parks. Here, Federal land managers are required by the Wilderness Act of 1964 and the Clean Air Act (CAA) of 1970 to preserve the natural conditions of these areas—that includes managing for clean air.

The Clean Air Act includes a program for prevention of significant deterioration of air quality—generally referred to as "PSD". This PSD program is designed to prevent areas currently having clean air from becoming too polluted. Wildernesses and National Parks established before 1977 are designated as Class I areas—allowing only very small increments of new pollution above already existing air pollution levels. Wildernesses established after August 7, 1977 are Class II areas, allowing for larger increments.

Working with PSD's

Specifically, the Forest Service is required by the CAA to report to the Environmental Protection Agency or the State the effects of proposed air pollution from new or modified major emission sources that may affect air-quality-related values (AQRV's) in Class I wildernesses managed by the Forest Service. Managers of Class I areas do this by reviewing applications called Prevention of Significant Deterioration (PSD) permits—a preconstruction review and permitting process for new or expanding sources of pollution. New source permit applicants submit plans to the permitting authority (usually the EPA or State), who examines the proposed location of the facility, it's general design, projected air pollution emissions, and potential impacts. If it appears that projected emissions may impact a Class I area, the EPA or State alerts the Federal land manager, who, in turn, determines the impact of the projected pollution level increases on the Class I area's AQRV's, and recommends approval, denial, or modification of the preconstruction permit.

Though sometimes difficult to obtain, lake assessment data are necessary to effectively implement the screening technique.

Not only is this a very involved process, but land managers often experience a general void of information to help them make these important determinations. Recognizing this need, Forest Service scientists, administrators, and other specialists last year sponsored a workshop designed to help land managers evaluate air pollution effects on Class I areas. The result was a procedure to screen permit applications, to help managers identify those applications that are likely to require more intensive study and consideration. The screening procedure uses estimates of sulfur and nitrogen deposition and ambient ozone concentrations to determine whether adverse effects on AQRV's could occur. In the procedure, these estimates are expressed as "green" and "red" lines on a graph. Pollutant doses less than the green line value might be judged permissible by managers, and the application recommended for approval. Doses above the red line value are likely to cause at least one AQRV to be adversely affected—resulting in a recommendation for denial, unless additional data are provided to prove otherwise. Doses falling between the red and green lines (yellow zone) would be evaluated on the basis of additional information.

Making it work

Land managers need six types of data to effectively implement the screening technique: (1) estimates of current deposition and air concentrations; (2) predicted deposition and air concentrations due to proposed source; (3) an inventory of biological resources associated with the AQRV's of the Class I area; (4) biological data on existing plant and animal species; (5) lake, stream, and soil survey/geological assessment; and (6) snowpack chemistry and hydrologic characteristics of the area. Alot of information, but necessary for an accurate evaluation. Some of this data can be obtained from published sources, local scientists, or university, State, Federal, and individual research personnel. However, wilderness managers will need to monitor their existing conditions to gather much of the information. Guidelines for doing so are available in *Guidelines for Measuring the Physical, Chemical, and Biological Condition of Wilderness Ecosystems*, General Technical Report RM-146, available from the Rocky Mountain Station.

Lake sampling in the Bridger Wilderness, Wyoming.

Report describes procedure

Results from the workshop, describing in detail the development and implementation of this process, have been published in a new report titled *A Screening Procedure to Evaluate Air Pollution Effects on Class I Wilderness Areas*, General Technical Report RM-168. The booklet also contains descriptions of nine wildernesses across the country, and discusses the AQRV's workshop participants attached to these areas, and why. Specific factors and considerations used in developing the process are also covered, including terrestrial and aquatic systems. The Rocky Mountain Station has copies.

The Forest Service's intent to use this screening process and to make it agency policy has been published in the Federal Register, Volume 54, No. 77, page 16382, April 24, 1989.

All Forest Service Regional Offices have been directed to develop screening procedures for each Class I area in their Region by: (1) identifying AORV's for each Class I area, and (2) organizing workshops to develop specific screening values for sulfur and nitrogen deposition, and ozone concentrations. Most Regions have either conducted or scheduled such workshops. If you would like more information on the workshops, contact James Byrne, Watershed and Air Management Staff, Forest Service-USDA, P.O. Box 96090, Washington, D.C. 20090-6090, (703) 235-8180, FTS 235-8180.

The GLEES study area is nestled in the Medicine Bow National Forest in southern Wyoming

For more information on the loading effects of sulfur, nitrogen, and ozone on wilderness ecosystems, contact Project Leader Doug Fox, Rocky Mountain Station, 240 W. Prospect Rd, Fort Collins, Colorado 80526, (303) 498-1231, FTS 323-1231.

Research continues

Finally, the Rocky Mountain Station is engaged in a long-term ecosystem-wide research effort to support the speculation and estimation that go into documents like the screening approach. A multidisciplinary team of research scientists has been working for the past three years to establish the Glacier Lakes Ecosystem Experiments Site (GLEES) for such research. GLEES is a high-elevation alpine ecosystem located on the Medicine Bow National Forest, west of Centennial, Wyoming, in the Snowy Range Mountains. The site is instrumented for meteorological, aerometric, deposition, snowmelt, and streamflow measurements as part of a holistic ecosystem research program.

Research into causes and effects, as well as development of models to simulate natural processes at GLEES, will continue to help quantify the estimations contained in the screening report.

Turning the tide of spruce budworm infestation

by Frances Reynolds
Intermountain Station

It's no small problem. The western spruce budworm (*Choristoneura occidentalis* Freeman) is estimated to infest 4 to 6 million acres of forest annually. It is the most widely distributed and destructive defoliator of coniferous forests in western North America, causing up to 20 percent loss of stand volume in susceptible forests, and some mortality.

This tenacious, highly adaptive insect doesn't need any help, but in the past has benefitted from an unwitting ally: forest managers. Scientists at the Intermountain Research Station (INT) are helping forest managers understand how past practices have encouraged the spread of the budworm. And they're finding ways to help them turn the tide of the budworm's progress.

Where did we go wrong?

Research by Clint Carlson (INT) and others has demonstrated that forest conditions have become much more favorable for the insect since intensive forest fire prevention and suppression policies were invoked in the early 1900's. Reduced fire frequency in the last 80 years has allowed shade-tolerant, budworm-susceptible conifers to become established over extensive, continuous areas. Before the 1900's, ground fires every 7 to 14 years removed susceptible understory trees.

Sixth-instar western spruce budworm just before pupation.

Past forest management practices also contributed to the development of susceptible forests. Selective harvesting removed high-value seral species, such as ponderosa pine, and left the stressed, often shade-tolerant conifers. Protected from fire, these low-vigor leftovers now occupy many good growing sites.

In the 1950's, resource managers began efforts to combat the budworm using "chemical warfare." Operational chemical treatment programs achieved local population reduction and reduced defoliation, but they did not change the course of outbreaks, or significantly reduce the continuing regional outbreak.

Now scientists are promoting the use of silviculture as a more integrated approach to managing the western spruce budworm. According to Carlson, "the silvicultural approach is appealing because it alters the forest substrate on which the budworm depends for survival." Developing this approach has required a great deal of research into the budworm's relationship to its environment.

The nature of the beast

As with all things in the natural world, budworm infestations involve the interaction of different environmental factors. Carlson and other Forest Service scientists working in the CANUSA-West Program to develop knowledge about the budworm identified eight major factors influencing budworm populations:

Multistoried residual stand of Douglas-fir, prime habitat for budworm

Regional climate

Outbreaks of budworm are generally associated with inland forests with drier, warmer climates where annual precipitation ranges from 9 to 36 inches. High-elevation stands that are very moist and cool are less susceptible.

Site climate

The interaction of slope, aspect, elevation, and physiography modifies climate at a specific site. Susceptiblity to western spruce budworm is greatest in stands on dry, warm sites with shallow soils.

Stand composition

Shade-tolerant conifer species including Douglas-fir, grand fir, subalpine fir, white fir, Engelmann spruce, and western larch are the primary food of the budworm; they are considered host species. Ponderosa pine, lodgepole pine, and others not used primarily for food can serve as overwintering niches for budworm larvae; they are considered nonhost species. Stand susceptibility and vulnerability increase as the proportion of hosts increases. Highly diverse stands with several tree species tend to be least susceptible and vulnerable.

The proportion and age distribution of shade-tolerant conifer species determine the successional status of a stand and, consequently, the susceptibility of the stand to budworm.

Generally, the most shade-tolerant conifers are the most susceptible. Stands with a high proportion of shade-tolerant species tend to be near climax and highly susceptible.

Susceptibility of western conifer forests is influenced by genetic variability within a species. No breeding experiments have yet led to the development of budworm-resistant trees.

Stand density

As density of host species increases, susceptibility apparently also increases. Dispersing budworm larvae moving down silken strings are less likely to reach suitable smaller trees in open than in dense stands. Larvae that fall to the ground likely starve or are eaten by predators such as ants and birds.

Height-class structure

Tree height variability significantly influences stand susceptibility. In multistoried, uneven-aged stands where intermediate canopies are host species, larvae are more likely to land on suitable substrate where they can feed and develop. One-storied seral stands appear to be the least susceptible.

Tree and stand vigor

Vigorous trees are less susceptible than trees under stress. One reason

may be that vigorous trees, having more foliage biomass, have a lower density of larvae per unit of foliage biomass, resulting in lower percent defoliation. Vigorous trees also appear to have a foliage chemistry that works against the insect.

Maturity of trees and stands

As trees age, they become larger and produce more substrate for feeding larvae. They become more suitable for egg deposition; produce flowers, which afford early habitat for small, feeding larvae; and become less susceptible to predators such as ants.

Continuity of host type

As the acreage of host type increases, the susceptibility of stands within or adjacent to that host type is assumed to increase. Large acreages of mature budworm-infested forest may produce large quantities of budworms that are dispersed by wind to nearby stands.

Knowledge gained about these factors influencing budworm populations has helped explain the increasing spread of infestation. Fire prevention and control policies and selective logging practices increased the biomass of shade-tolerant conifers; maintained low-vigor trees; created multistoried canopies; increased stand density and, therefore, moisture stress in the stand; increased the proportion of host to nonhost; and increased the continuity of surrounding host type.

Nondestructive exams of plot trees following thinning treatments provide valuable clues about budworm activity.

The silvicultural approach

Silvicultural treatment employs knowledge of these factors to remedy the errors of the past. It isn't a quick solution, though. Carlson explains that silviculture represents a long-term approach to the budworm problem by minimizing susceptiblity of conifer forests to infestation.

Silvicultural practices can have some immediate effects. However, minimizing the susceptibility of conifer forests over a broad expanse of the Rocky Mountain West is a long-term objective," he cautions. "Silvicultural practices can create more vigorous forests, while creating a habitat and environment less favorable to the budworm."

The effectiveness of the silvicultural approach, Carlson points out, depends on setting priorities. Forests are composed of mosaics of stands ranging from high to low susceptibility. Individual stands must be rated for susceptibility, and priorities set to treat the most susceptible first. *Rating the Susceptibility of Stands to Western Spruce Budworm: A User's Guide and Documentation to Western Spruce Budworm Hazard*, published by the Northern Region of the Forest Service, helps managers with this first step.

Silvicultural treatments will vary, of course, with the characteristics of individual stands. In each case, however, the objective is to create an environment that discriminates against the budworm. Treatments should reduce the numbers and percent composition of the budworm's primary hosts and manipulate habitat for maximum larval mortality during dispersal, minimum egg-laying sites, and enhanced habitat for predators.

For highly susceptible mature stands, for example, even-aged harvest methods—clearcut, seed-tree, and shelterwood—are particularly effective in altering the factors influencing stand susceptibility. Species composition is changed and seral conifers with low susceptibility to budworm can be favored; stand density is reduced, increasing the loss of larvae during dispersal and

reducing the number of sites for egg deposition; variation in crown within the residual stand, such as shelterwood, is reduced, contributing to larvae losses during dispersal; the continuity of host types is broken. Even-aged harvest methods also have the immediate effect of reducing the quantity and quality of budworm habitat.

By contrast, the treatment generally appropriate for pole-sized stands involves commercial and precommercial thinning. Thinning serves to decrease density in these often overstocked stands. It improves tree vigor, increases the proportion of seral hosts and nonhosts, and reduces diversity in height-class structure. Again, the treatment creates conditions less suitable to the budworm.

Silvicultural practices found to be most effective in combatting budworm infestation include emphasizing stand diversity in species composition by favoring seral trees and discriminating against most shade-tolerant host trees; regulating stand density through release cuttings and thinnings; creating even-aged stand structures; removing overwood trees when regeneration is established; removing diseased and heavily infested trees; removing the most heavily defoliated trees; and regenerating host stands at or before biological maturity. Ground fires also reduce budworm habitat by removing understory trees.

Continuing research is revealing interactions between stand conditions, budworm, and the chemistry of Douglas-fir foliage.

It will take time. Turning the tide of western spruce budworm infestation will take dedication and perseverance, too, but the effort is worth the reward. The silvicultural approach of reducing budworm susceptibility promises long-term protection of the vast and valuable forests of the northern Rockies.

A recent publication by Carlson and N. William Wulf, *Silvicultural Strategies to Reduce Stand and Forest Susceptiblity to the Western Spruce Budworm*, Agriculture Handbook No. 676, provides more information on this subject. Information may also be obtained from Clint Carlson, Forestry Sciences Laboratory, P.O. Box 8089, Missoula, Montana 59807. Telephone (406) 721-5694.

Douglas-fir old growth as habitat

by Cynthia Miner
Pacific Northwest Station

The most respected of natural resource specialists once viewed old-growth forests as "biological deserts." With the emergence of scientific information about old growth in the last 20 years, these forests are now seen to be abundant with life. One facet of old growth of special interest to resource managers is how these forests serve as plant and wildlife habitat.

Since 1983, researchers from the Pacific Northwest and Pacific Southwest Research Stations, the Fish and Wildlife Service, and several universities have been conducting studies of old growth as part of a wildlife research effort led by the Pacific Northwest Research Station, Forestry Sciences Lab, Olympia, Washington. Researchers in the effort came together in Portland, Oregon, in March 1989, to make 39 presentations at a symposium. Together the researchers provided the first comprehensive look at old growth as plant and wildlife habitat in Oregon, Washington, and northern California.

Understanding key structural features of old-growth forests (large old-growth trees, large snags, and large downed logs) helps resource specialists make decisions about second-growth stands in addition to old-growth stands.

The path of study

A variety of old growth exists in the West and throughout the United States. The research effort has focused on late-successional Douglas-fir forests where a community perspective of animals and plants has been taken. Researchers examined three groups of wildlife for which there were large gaps in scientific knowledge: amphibians, small mammals, and diurnal birds.

The researchers designed their studies for a search of species that depend on or find optimum conditions in the old growth. They classified stands by three age classes. The age range of these classes varied by study but generally were young, 40-79 years; mature, 80-194 years; and old growth, over 195 years. The studies were conducted in the southern Washington Cascade Range, western Oregon Cascades, Oregon Coast Ranges, and the Klamath Mountains in southwestern Oregon and northwestern California.

Because few large contiguous stands have been managed under modern practices for more than 30 years, large managed stands were not available for scientific sampling.

Managed stands have little resemblance to natural stands, and the studies, therefore, do not allow comparisons of managed with natural conditions. The studies of natural stands, nonetheless, shed light on significant wildlife features and provide baseline information for improving the quality of managed forests.

Natural history of the forest

In western Oregon and Washington and northwestern California, Douglas-fir flourishes as a seral and late-successional species in stands for 350-600 years and may persist until 800-1,000 years. Forests over 800 years old are, however, infrequent because of wildfire and timber cutting.

Lightening fires have historically been the origin of Douglas-fir stands, creating landscape patterns that differ from north to south, moist to dry sites, and high to low elevations. The patterns of Douglas-fir are recent in evolutionary terms, with a history of 10 to 20 generations of Douglas-fir. These stands first appeared with postglacial warming about 6,000 years ago. Because the forest type is relatively young, species may not have yet evolved into the tightly bound biological complex found in very old types, such as tropical rain forests.

The plant community: distinct

All old-growth forests are not the same even within the same forest type and vary greatly by geographical location and site moisture. In the ecological characteristic of composition, old-growth forests have distinct complements of flora and fauna. Function, another ecological characteristic of old growth, includes productivity, effects (on erosion, for example), and wildlife habitat. Research has shown that old-growth forests are highly productive as they maintain large amounts of living matter, and in the long run growth and mortality tend to be balanced.

Key structural characteristics (the third ecological characteristic, which determines the compositional and functional attributes) are large old-growth trees—including some with broken tops, large snags, and large downed logs on the ground and in streams. Old-growth is most distinct in its canopy structure (tree size and presence of shade-tolerant canopy structure). Researchers found coarse woody debris was prevalent in both young and old-growth stands—many young stands inheriting their dead wood from previous old-growth stands.

In examining old growth as plant habitat, researchers found plant species richness to be somewhat higher in old growth than in the younger age classes. At least several plant species seem to find optimal conditions in old growth. In particular, Pacific yew and one species of canopy lichen were much more abundant in old growth than in other age classes. Shade-tolerant herbs, such as bunchberry and coolwort foamflower, were also more abundant in the dark, cool understories of old-growth forests.

Hidden amphibians

Although often unseen, amphibians are some of the most abundant animals in the study areas. In the Oregon Cascades, for example, 2,833 individuals per acre were found. The studies show amphibian (as well as small animal and bird) communities differ by geographical area, elevation, moisture, and in some areas by age class.

Clouded salamanders were generally associated with old-growth forests in the Oregon Coast Ranges. In the southern Washington Cascade Range, the northwestern salamander, roughskin newt, and Cascades frog were mostly found in old growth. In California, five species of amphibians reached their highest abundances in old-growth: ensatina, California slender salamander, Del Norte salamander, Olympic salamander, and the tailed frog. The Del Norte salamander, Olympic salamander, and tailed frog (one of the world's most primitive frogs) occurred almost exclusively in mature and old-growth forest.

The tailed frog was found to occur almost exclusively in mature and old-growth forests in northwestern California. (Photo by Hartwell Welsh, Pacific Southwest Research Station)

Amphibians, depending on their breeding habits, use headwaters, ephemeral ponds (those created yearly by snowmelt), and woody debris at different stages of decay. The clouded salamander, for instance, prefers large Douglas-fir logs with the bark still attached, and Oregon slender salamanders and ensatinas prefer well-decayed logs. Also associated with downed logs are the western redback salamander and possibly the red-legged frog. Stream-breeding amphibians include the Olympic salamander, tailed frog, and Pacific giant salamander.

Amphibians can probably be best maintained by keeping headwaters and streams unsilted and cool. Ephemeral ponds need to be recognized and protected, and downed wood managed.

Small mammals: from ground to canopy

Small mammals seem to have adapted to a broad range of age class and moisture in naturally regenerated forests, with great variation across geographical areas. Most obvious is greater species richness of mammals in Oregon than in Washington. (This is also true for birds and amphibians.)

Other results that illustrate geographic variation include the following: Bat activity was higher in old growth than young stands, particularly in Oregon where bat habitat in the Coast Ranges was especially important. Flying squirrels were twice as abundant in old growth as in young stands in the Coast Ranges, but not in western hemlock forests of the Olympia Peninsula. In California, the red-backed vole was strongly associated with old growth. The red tree vole and shrew-mole were most associated with old growth in both Oregon and Washington.

The habitat needed by small mammals differs in natural forests. Some species associated with old growth select sites with a high percentage of lichen ground cover. Decaying logs and snags are especially important to several of the mammals. Two species of shrews are associated with downed wood in California. The California red-backed vole has a strong preference for decaying logs in young and old stands. Damaged and diseased trees and snags appear to be important to bats, which may use old-growth stands as roosting sites.

Diurnal birds in the depth of the canopy

In Cascade community studies, patterns of populations were again more related to geographic variation than to age class. Many species were more abundant in old growth than in the other two age classes.

Yet, most of these species were also found in significant numbers in the other age classes. The Vaux's swift is an exception and may be dependent on old growth. Also, in the Oregon Coast Ranges, the hairy woodpecker, marbled murrelet, olive-sided flycatcher, pileated woodpecker, red-breasted sapsucker, and spotted owl were abundant in old growth while being uncommon or absent in young stands.

Birds flourish in the dense, multilayered old-growth canopy. The deep, extensive furrows of bark serve as habitat for arthropods that in turn are food for birds. Snags are used for feeding, nesting, and perching.

Some of the birds that use old-growth snags are the northern flicker, pileated woodpecker, hairy woodpecker, red-breasted sapsucker, chestnut-backed chickadees, Vaux's swfft, red-breasted nuthatch, and brown creeper. Each of these species has its own preference in snags; for instance, chestnut-backed chickadees prefer remnants of snags from past stands found in young stands, and brown creepers prefer snags with some branches.

The pileated woodpecker uses old-growth snags and, in the Oregon Coast Ranges, is most abundant in old-growth but uncommon or absent in young stands.

In studying birds, the researchers mostly examined spring breeding communities. Because many of the birds in the Douglas-fir forest are permanent residents, winter habitat is particularly important. The one winter study found greater species richness and abundance in old growth than in other age classes. Four species were strongly associated with old growth in the winter: red crossbill, chestnut-backed chickadee, red-breasted nuthatch, and gray jay.

Summary

A research effort, led over the last several years by the Forest Service, has created a new and comprehensive understanding of late-successional Douglas-fir as habitat for plants, amphibians, small mammals, and diurnal birds in the Pacific Northwest and northern California. Old growth as wildlife habitat is complex, and animal associations vary, particularly by geographical locations. Snags, downed wood, headwaters, and ephemeral ponds are important habitat features.

The studies show that more than 20 species of amphibians, diurnal birds, and small mammals and at least several plant species thrive more in old growth than in young or mature natural forests. Most of these species also have significant populations in other age classes of natural forests. A few, such as the Vaux's swift, seem to depend on old growth.

The information in this article comes from the papers and abstracts presented by many scientists at the symposium "Old-Growth Douglas-Fir Forests: Wildlife Communities and Habitat Relationships." A book based on the papers presented at the symposium will be available in spring 1990 from the Pacific Northwest Research Station.

Saving Hawaii's native forests

by J. Louise Mastrantonio
for Pacific Southwest Station

Five years ago, George Markin was sent by the U. S. Forest Service to Hilo, Hawaii. Not bad duty if you don't mind two-hundred inches of rain a year and a job that some might describe as nearly impossible.

Markin is a research entomologist and the Forest Service member of a loosely-organized cooperative effort that has just one goal: stop an invasion of weeds that threatens to destroy what is left of Hawaii's native rainforest. No chemicals or mechanical means are to be used, only the natural insect and disease enemies of the plants themselves. In this, Markin is breaking new ground. This is the first time biological control (using insects) of forest weeds has been used in an attempt to save native ecosystems.

"If we can't stop this invasion of plants, our native forests will be gone in a hundred years," Markin says. Ironically enough, invasion played a major role in the development of Island ecosystems. Even as the volcanic islands began to form, they were colonized by birds and plants that managed to travel long distances and gain a tenuous foothold. These species evolved into a rich and unique biota unlike that found anywhere else in the world.

Eventually, invasion got out of hand. Around 1,600 years ago, the early Polynesians arrived—bringing with them domesticated animals such as pigs, dogs, and chickens, rats, and plants such as taro, breadfruit, sweet potato, banana, and coconut. These introductions, along with forest clearing, fire, and other practices, began to damage the original Island ecosystems.

Typical infestation of the vine, banana poka (passiflora mollissima), covering trees and shrubs in Hawaii forests.

But it was the coming of Europeans that sounded the death knell. When Captain Cook arrived in 1778, there were at least 1,400 native species of seed-bearing plants in the Islands. Since then, more than 4,000 have been introduced. Many of those have become naturalized. Europeans also brought hoofed animals—cattle, goats, pigs, sheep and horses. They were protected by the Polynesians and consequently ran wild. As a result, many native plants and birds have been lost and the ecosystems disrupted.

Only a small portion of Hawaii's original rainforest remains. For the most part, it is protected in National Parks, state forests, and other reserves. Ranchers and other landowners are no longer clearing forests to create pastures, and landowners are putting up fences to control wild cattle, pigs and goats. Weeds are another major threat. Some introduced plants are so aggressive they theaten to destroy even the native koa and ohia forests. Twenty-four plants are now considered noxious weeds in Hawaii's forests, parks and natural reserves.

Biological control a promising solution

In 1983, amid growing concern about the future of Hawaii's native ecosystems, representatives of several organizations (the U. S. Forest Service, National Park Service, State Departments of Forestry and Agriculture, and the University of Hawaii) met to discuss the problem. What they came up with is a long-term program of biological control. All the organizations participate by providing funding, staff, or services.

Markin's role in this effort is to run an insect quarantine facility where foreign insects can be raised and evaluated as candidates for control purposes. He divides his time between an office in Hilo and the Hawaii Field Research Center in Hawaii Volcanoes National Park. Each time he makes the thirty mile drive up the mountain between Hilo and the Park, the entomologist has a good look at the problem.

"This is the one of the most cosmopolitan forests in the world," he says, stopping along the road to point out plants that hail from nearly every continent: Asia, Africa, Australia, South America, Europe, India. "There's no other place on earth where you can see this. In a hundred years, this invasion will stabilize and you'll have a new, man-made ecosystem." In the Park, however, and in many other reserves, the goal is to maintain as much of the native forest as possible.

Adult of the moth, Cyanotricha necyria. *Larvae of this moth feed on the foliage of this very destructive vine. The moth was originally collected in Columbia, South America, tested in our quarantine and a permit for release issued by the Hawaii Department of Agriculture. It is presently being mass reared and released on the island of Hawaii and Kauai.*

Rearing enemy insects

Currently, Markin is screening insects for control of five major weeds:

- Banana poka (*Passiflora mollissima*), a tendral, woody vine of the tropical montane forests of the high Andes in South America. Brought to Hawaii around 1900 as an ornamental, banana poka is now well established in three areas on the Big Island and on Kauai and Maui. Some 120,000 acres are affected. In dense growth, the vine can smother and kill even the tallest trees.

- Faya tree (*Myrica faya*), a small decidious tree of the Azores, Madeira, and Canary Islands. Once considered for reforestation purposes, it was soon recognized as a weed. It now poses a major threat within Hawaii Volcanoes National Park.

- Asian raspberry (*Rubus ellipticus*), a thorny cane native to the Himalayas. Related to, but more aggressive than the domestic raspberry, *Rubus* forms impenetrable stands and is a threat even to undisturbed forest because it is spread by birds and can grow in the understory.

• Gorse (*Ulex europaeus*), a spiny European shrub probably introduced in Hawaii around 1900 along with sheep ranching. Gorse is established on about 50,000 acres on the island of Hawaii and on Maui. A remarkably hardy and aggressive plant, it commonly invades areas disturbed by fire or cattle grazing.

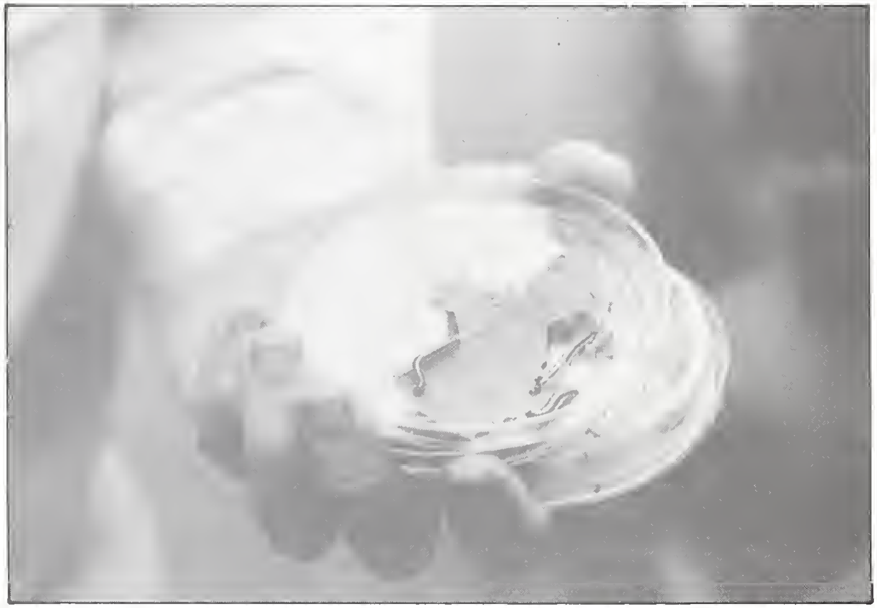
• Koster's curse (*Clidemia hirta*), a dense-growing ornamental shrub native to Central and South America, forms thickets and smothers other vegetation. *Clidemia* is established on all of the larger islands.

Battle plan

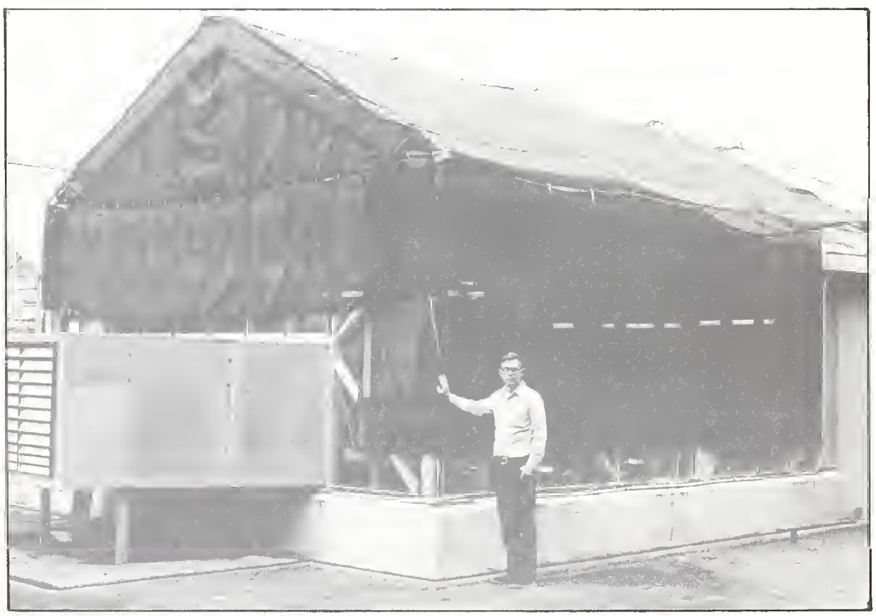
Getting rid of these weeds will require hard work, patience, and adherence to some well established procedures: 1) Develop an understanding of the target weeds and their native habitats; 2) Identify promising control agents in the countries of origin and study their biology; 3) Screen candidate control agents for effectiveness and obtain permission to release them; and 4) Evaluate their effectiveness and release them in large quantities.

Banana poka moth trials

At the field laboratory, Markin opens a petri dish to display a small insect. It is the caterpillar of the banana poka moth (*Cyanotricha necyria*), a defoliator that feeds on leaves of the vine. In South America, where banana poka is grown commercially, outbreaks have been known to devastate an entire crop. The moths were sent to Markin by South American cooperators who also identified several other insects as possible biocontrol candidates.



*Markin with petri dishes holding caterpillars of the banana poka moth (*Cyanotricha necyria*), the first insect tested at the quarantine facility and a prime candidate for biological control.*



Entomologist George Markin in rearing facility at Hawaii Field Research Center. Plants are grown and used in tests to determine insects' feeding habits.

At the quarantine facility, Markin learned how to rear them and began screening tests to determine their feeding habits.

Markin is quick to dispel fears that the moths might somehow develop a taste for other plants. "We know they won't eat anything else," he insists. He has tested more than a hundred different plants, including closely-related species, native plants, and those grown commercially in Hawaii.

After three years of testing, the Hawaii Board of Agriculture finally approved release of the moth. The first release was made in February 1988 at Laupahoehoe on the east slope of Mauna Kea on the Island of Hawaii. Moths will continue to be released at various locations until Markin can determine if they are becoming established. But it will be five to ten years before researchers know the results. "You put ten thousand moths on a hundred thousand acres," Markin says. "That's one insect in ten acres. It's going to be a while before we know if this is successful."

Goal is successful competition

This procedure will be followed numerous times in the coming years as Markin and his cooperators continue to develop new candidates for biocontrol. Even as the banana poka moths are being released, others are being studied. The goal is to find insects that feed on different parts of the plant and at different growth stages.

Markin is pleased, too, with progress on gorse. There, he's tapping into a long history of work that includes release of the gorse seed weevil back in the 1950's. Unfortunately, the weevil was killed along with the gorse during a subsequent eradication program. "Now we have more gorse than we ever did, but no weevils" he laments.

Markin reintroduced the weevil on the island of Hawaii about four years ago. Since then, it has multiplied rapidly and is beginning to do some good. The first release of another insect, a moth that feeds on the foliage, was made in November 1988. In quarantine, four more insects are being tested. "Two of those look real good," he says. "I wouldn't be surprised if we get a permit for their release in two or three years."

What Markin is doing, in effect, is developing an ecological support system that will enable Hawaii's native species to compete successfully with the weed plants. That's the goal—not complete eradication.

Markin at rearing facility. Insects are raised in isolation cages in quantity and will later be released in the forest.

Biological control is accepted now by the Department of Agriculture as a method of controlling unwanted species. Hundreds of insects have been successfully controlled that way and results with plants are also encouraging. As early as 1902, insects were used to control lantana, a thorny shrub that once infested vast areas of dry lowlands. Since then, the State has approved biological control for twenty-one different weeds. In ten of those, control has been considered effective.

"They're gone," Markin indicates. You really have to hunt to find them now."

He hopes one day that can also be said of banana poka, gorse, faya tree, Asian raspberry, clidemia, and maybe all twenty-four of those pesky plants on the forest and park managers' most unwanted list.

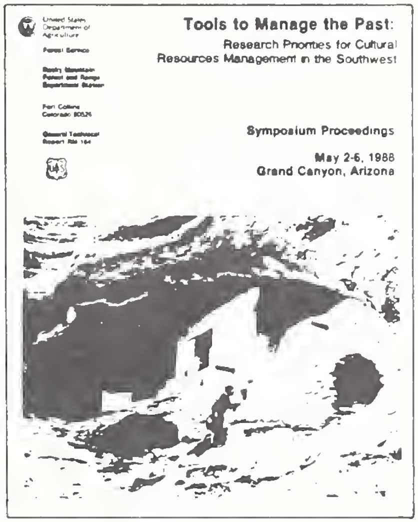
New from research

Managing cultural resources in the Southwest

The Southwest is home to a vast array of cultural resources. They include prehistoric cliff dwellings, pueblo ruins, Spanish colonial and Mexican settlements, and various types of early mining, ranching, and logging sites. Many of these resources can be traced forward into modern times to contemporary Native American populations still occupying these lands. They are unique to North America and represent scientific, historical, and religious treasure of incalculable value.

With this in mind, the Forest Service recently sponsored a symposium to establish what knowledge and technology is needed to better understand and manage cultural resources in the Southwest.

At the five-day gathering, at Grand Canyon, Arizona, 57 participants representing more than 20 government agencies, educational institutions, and other public and private organizations discussed topics ranging from designing coordinated research, to actually implementing it. A number of important management recommendations also emerged. The papers represent a consensus on what the research needs are, and are a good cross-section of contemporary concerns in archeology and cultural resource management. Management impacts, Native American heritage,



protection and preservation, site discovery and definition, public interpretation and education, key prehistoric and historic research, and integrated research designs are discussed.

If you would like a copy of the proceedings, contact the Rocky Mountain Station and ask for *Tools to Manage the Past: Research Priorities for Cultural Resource Management in the Southwest*, General Technical Report RM-164.

Using microclimate against the mountain pine beetle

Thinning is sometimes used to reduce mountain pine beetle infestations in lodgepole pine stands. The increased resistance of residual trees has been thought to be the result of improved vigor.

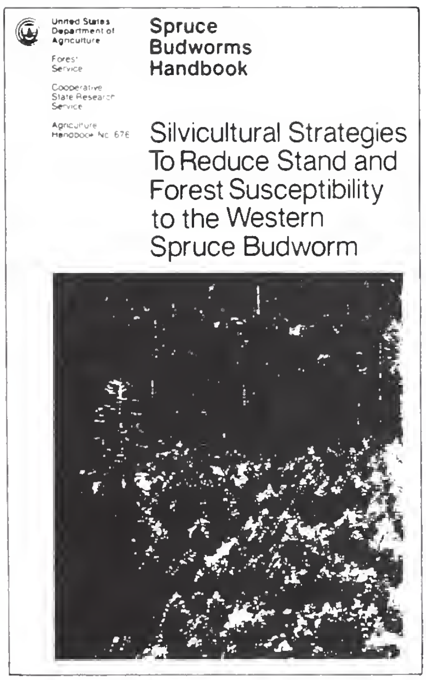
Recent research by scientists at the Intermountain Station suggests that thinning works by creating changes in stand microclimate that have profound behavioral effects on the insect. A new research paper discusses changes in temperature, incident solar radiation, windspeed, and wind direction observed in a thinned stand, and the apparent effects of these changes on mountain pine beetle activity.

Beetle response—only 5 percent of the total insects were caught in traps in the thinned stand, and mortality was much less—suggests the usefulness of monitoring stand microclimate to assess infestation risk.

Request *Microclimate: an Alternative to Tree Vigor as a Basis for Mountain Pine Beetle Infestation*, Research Paper INT-400.

Silvicultural tactics for the western spruce budworm

A new agriculture handbook has been published that details silvicultural treatments that can significantly reduce forest and stand susceptibility to the western spruce budworm.



A tremendous amount of budworm habitat exists in the western U.S. and Canada, but all habitat is not equally suitable. The authors discuss a new rating system based on factors known or presumed to contribute to budworm habitat quality. The variation in habitat quality can be indexed, and provides the land manager with a basis by which to set treatment priorities.

The 31-page book covers factors affecting budworm habitat; rating and altering stand susceptibility to budworm; and strategies for reducing forest susceptibility.

The Rocky Mountain Station has copies. Request Silvicultural Strategies to Reduce Stand and Forest Susceptibility to the Western Spruce Budworm, Agriculture Handbook No. 676.

New sourcebook guides campsite monitoring

For wilderness managers, recreational use on campsites presents a challenge in protecting natural conditions. The first step in controlling campsite impacts is to document campsite conditions and how they are changing over time. A sourcebook is now available that summarizes information on techniques that have been developed for monitoring campsites, particularly those in wildernesses and backcountry.

The sourcebook is organized into a series of steps that must be taken in developing a monitoring system. They include (1) evaluating system needs and constraints, (2) deciding on impact parameters and evaluation procedures, (3) testing monitoring techniques, (4) training and documentation, (5) collecting field data, (6) analyzing and displaying data, and (7) applying data to management. For each step, existing techniques are described and evaluated, problems are discussed, and sources of information are listed. Detailed descriptions of representative examples of monitoring approaches are included in an appendix.

Request *Wilderness Campsite Monitoring Methods: A Sourcebook*, General Technical Report INT-259 from the Intermountain Research Station.

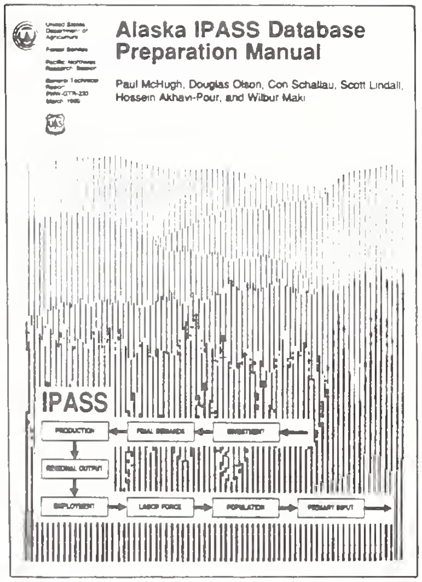
Software for analyzing policy impacts

Policy for managing forest resources is shaped continually by decisionmakers and events. The variables that go into making policy may seem limitless. Yet tools exist for making these variables manageable and useful. The interactive policy analysis simulation system (IPASS) is one such tool for policy analysts, planners, researchers, and educators.

The IPASS system forecasts growth and development of an economy for a specified time. The system can be used to examine long-term economic and demographic effects of policy alternatives in forest resource management. The user selects parameters for different assumptions about socioeconomic variables. The impact of the resulting changes are analyzed by comparing alternatives with original forecasts.

Input (parameters and variables) includes statistics on employment, population, earnings, productivity, and annual rates of change, such as hours worked per week. The user is required to compile a data base of about 100 socioeconomic parameters and variables for the region being studied. The system has been available for several years. Recently, however, a manual for gathering and formating this data has been issued by the Pacific Northwest Research Station. The manual also provides knowledge of the data and its limitations. Although an Alaska database is used, the manual is a guide for other areas and for economic data reduction activities in general.

IPASS is available for microcomputers with MS-DOS or PC-DOS. The system is interactive and requires no programming or model-building experience. For a description of IPASS and the users manual, request General Technical Report PNW-170 *IPASS: An Interactive Policy Analysis Simulation System*. For the manual on preparing data for IPASS, request General Technical Report PNW-233 *Alaska IPASS Database Preparation Manual*. Both publications are available from the Pacific Northwest Research Station.

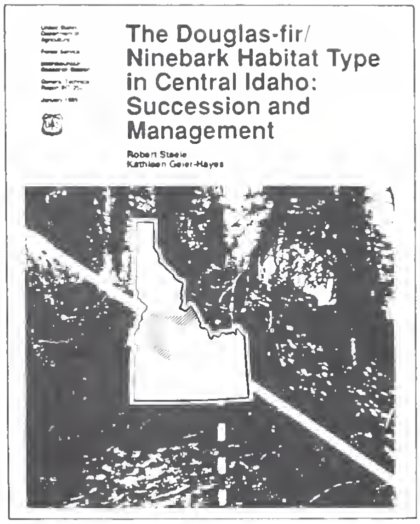


For a copy of the program, contact Douglas C. Olson, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3200 Jefferson Way, Corvallis, OR 97331.

Douglas-fir/ninebark classification will aid forest managers

A new report from the Intermountain Station, the second in a series on succession and management of forest habitat types, presents the seral vegetation and related resource values occurring over time in the Douglas-fir/ninebark habitat type. The succession classification approach, designed for general field use, accomodates the individual nature of specific sites in terms of existing and potential species composition. It also accomodates the land manager's need for site-specific guidelines for intensive management purposes.

The classification system recognizes the somewhat independent nature of succession between the tree, shrub, and herbaceous layers, and treats these three successions separately. A total of six potential tree layer types, 28 shrub layer types, and 55 herbaceous layer types are categorized. Diagnostic keys based on indicator species are provided for identification of the layer types.



Implications for natural resource management are provided. They include: occurrence of pocket gophers and success of tree plantations by site preparation treatments, initial growth rates of tree seedlings and yield capability of mature trees, microsite site needs of natural tree seedlings, big-game and livestock forage preferences of shrub and herb layer types, and response of major shrub and herb layer species to various disturbances.

Request *The Douglas-fir/Ninebark Habitat Type in Central Idaho: Succession and Management*, General Technical Report INT-252.

An overview of managing spruce-fir forests

The Rocky Mountain Station has issued a report that summarizes and consolidates the ecological, silvicultural, and managerial knowledge about Engelmann spruce-subalpine fir forests in the central and southern Rocky Mountains.

These forests are the predominant multiple-use forests in this part of the country. They are a large and productive timber resource, occupying the highest potential water-yielding areas, and providing wildlife habitat, livestock forage, recreation, and outstanding scenic beauty.

This publication presents a detailed summary of the ecology, resource, silvics, silviculture, and management of spruce-fir forests. Major emphasis is on the silviculture and management of old-growth and the establishment of new stands.

For your copy, write the Rocky Mountain Station and request *Ecology, Silviculture, and Management of the Engelmann Spruce-Subalpine Fir Type in the Central and Southern Rocky Mountains*, Agriculture Handbook 659.

Predictions of streamflow responses can be improved

Many National Forest hydrologists in the northern Rockies use some adaptation of the equivalent clearcut area (ECA) procedure to forecast average streamflow response to vegetation removal by timber harvesting, road building, and fire. Effects of past activities on streamflow can be estimated, and a schedule of entry developed for future activities that manipulate vegetation. In adapting the procedure to reflect local conditions, hydrologists generally rely on limited local data or data extrapolated from other areas.

Study results published by the Intermountain Station compare actual streamflow responses to predicted responses in four small watersheds, and show that increases in water yield on areas in equivalent clearcut condition were substantially higher than predicted. Results emphasize the need for reliable local precipitation and streamflow data to develop the accurate relationships for use in the ECA procedure. Relationships developed in the study may be applicable to many northern Idaho sites if local relationships have not been developed.

United States Department of Agriculture

Forest Service

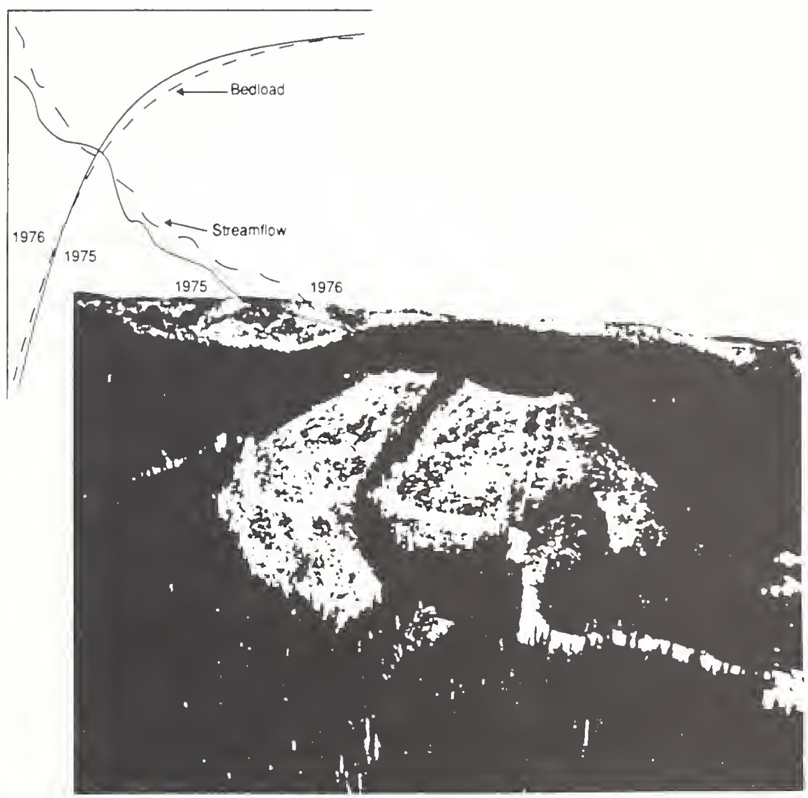
Intermountain Research Station

Research Paper INT-401

April 1989

Streamflow Responses to Road Building and Harvesting: a Comparison With the Equivalent Clearcut Area Procedure

John G. King



The study also examines ECA limits on expected increases in maximum monthly streamflow during spring snowmelt. The limit is intended to prevent increases in high streamflows that could potentially damage or alter a channel. Study results demonstrate that high streamflows of relatively short duration are responsible for the majority of sediment load transport and have potential to modify a channel. Limits on expected increases in instantaneous peak or maximum daily streamflows are recommended for channel protection, rather than limits on monthly streamflow increases.

Request *Streamflow Responses to Road Building and Harvesting: a Comparison with the Equivalent Clearcut Area Procedure*, Research Paper INT-401.

Software for determining tree and stand values

For specialists who want to examine tree and stand values, an interactive microcomputer program has been made available by the Pacific Northwest Research Station. The Tree Value System (TREEVAL) calculates tree and stand values and volumes based on product prices, manufacturing costs, and predicted product recovery. The system is for use on an IBM-compatible microcomputer.

The current system predicts the product value of natural stands of limited silvicultural manipulation. Although developed for financial evaluations of stand management decisions, the system can also be used for appraisals and evaluating log bucking. The analyst uses either an option for optimal tree bucking or simulated bucking based on his or her specified bucking rule.

Another use for TREEVAL is sensitivity analyses. For example, the following questions can be asked: At what relative prices for lumber and veneer would the increased value of products justify the cost of additional sorting of logs? Or, what is the effect of a 10-percent increase on the prices for veneer relative to lumber?

Although the recovery equations in the current system are appropriate only for natural stands of coast Douglas-fir, TREEVAL can be used with other species if the user inputs appropriate recovery equations for the species. A new version of TREEVAL is being developed that will have recovery equations for evaluating silvicultural regimes for coastal Douglas-fir plantations.

For *Tree Value System: Description and Assumptions*, request General Technical Report PNW-239. For *Tree Value System: Users Guide*, request General Technical Report PNW-234. For information on ordering a copy of the program, contact Forest Resources Systems Institute, 122 Helton Court, Florence, Alabama 35630 or (205) 767-0250.

Research on Sitka black-tailed deer synthesized

Wildlife biologists and other resource specialists often approach forests with the question: How does this area serve as wildlife habitat? In Alaska and British Columbia habitat of particular interest is that of the Sitka black-tailed deer.

A major research effort was undertaken from 1981 through 1986 to examine the nutritional ecology of the Sitka black-tailed deer in western hemlock-Sitka spruce stands of Alaska. A synthesis of this research with practical interpretation for forest management has recently been issued by the Pacific Northwest Research Station.

Researchers took a nutritional approach by assuming that foraging efficiency provides the best single measure of habitat quality for an individual deer. From their research results, the authors of the synthesis recommend habitats be evaluated primarily by nutritional estimates of carrying capacity and that more emphasis be placed on summer and spring range than is currently done. Winter range remains, however, an important feature of habitat management. Even-aged stands need to be managed for a continuous mix of open clearcuts and forests for deer habitat, with small clearcuts and a mixture of many different age classes. Retention of noncommercial old-growth stands and commercial stands for habitat protection are important in maintaining habitat diversity.

For a copy of *Forest Habitats and the Nutritional Ecology of Sitka Black-Tailed Deer: A Research Synthesis with Implications for Forest Management*, request General Technical Report PNW-230 from the Pacific Northwest Research Station.

To order any of the publications listed in this issue of *Forestry Research West*, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

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1. *Tree Value System: Description and Assumptions*, General Technical Report PNW-239.
2. *Tree Value System: Users Guide*, General Technical Report PNW-234.
3. *IPASS: An Interactive Policy Analysis Simulation System*, General Technical Report PNW-170.
4. *Alaska IPASS Database Preparation Manual*, General Technical Report PNW-233.
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3. *Silvicultural Strategies to Reduce Stand and Forest Susceptibility to the Western Spruce Budworm*, Agriculture Handbook No. 676.
4. *Tools to Manage the Past: Research Priorities for Cultural Resource Management in the Southwest*, General Technical Report RM-164
5. *Ecology, Silviculture, and Management of the Engelmann Spruce-Subalpine Fir Type in the Central and Southern Rocky Mountains*, Agriculture Handbook No. 659.
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2. *Microclimate: An Alternative to Tree Vigor as a Basis for Mountain Pine Beetle Infestation*, Research Paper INT-400.
3. *Wilderness Campsite Monitoring Methods: A Sourcebook*, General Technical Report INT-259.
4. *The Douglas-fir/Ninebark Habitat Type in Central Idaho: Succession and Management*, General Technical Report INT-252.
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Strategies for revegetation of grasses examined

A recent Intermountain Station research paper examines the effects of introduced grass seeding density and fertilizer on the establishment of native grass species on drill pad sites. Differences in first-year seeding density and 3-year standing crop biomass among treatments are evaluated for seeded introduced grasses and native grasses and for unseeded colonizers. The paper discusses findings that density of introduced grasses did not lower establishment or growth of native species, which is the objective of many mined-land revegetation projects.

Introduced grasses, native species, and colonizers all showed large initial responses to fertilizer. However, after levels of soil nutrients had decreased in fertilized treatments, introduced species showed a larger relative decrease in standing crop biomass than native species, and colonizers had the largest decrease of all. Many native species are adapted to lower nutrient levels. They show smaller responses to fertilizers, and can maintain productivity at lower levels of nutrients.

The paper concludes that reclamation strategies for nutrient-deficient soils should be determined by the site's inherent regenerative capacity and the desired end land use.

United States Department of Agriculture

Forest Service

Intermountain Research Station

Research Paper INT-402

March 1989

Native Species Establishment on an Oil Drill Pad Site in the Uintah Mountains, Utah: Effects of Introduced Grass Density and Fertilizer

Jeanne C. Chambers

Request *Native Species Establishment on an Oil Drill Pad Site in the Uintah Mountains, Utah: Effects of Introduced Grass Density and Fertilizer*, Research Paper INT-402.

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